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ADVANCED PARTICULATE AND MERCURY REMOVAL TECHNOLOGY

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ABSTRACT

Historically, coal-fired boilers have utilized electrostatic precipitators for particulate removal. As environmental regulations become more stringent and enforcement becomes more consistent, electrostatic precipitators are challenged to provide continuous compliance.

As a result, many coal-fired boiler operators are considering pulse jet fabric filters to provide continuous particulate compliance. However, there can be operational penalties experienced when this switch is made.

Traditional pulse jet fabric filters introduce increased pressure loss to the system. This loss is in the range of 150 to 250 mm of water. In addition, compressed air used to pulse the filters can account for a major operating expense. The requirement to replace filter bags every three to four years is a major expense.

Based on the need to increase particulate removal efficiency while minimizing the impact on plant operating costs, an alternative to a conventional pulse fabric filter is required.

MAX-9™ ELECTROSTATICALLY ENHANCED FABRIC FILTER

The United States Environmental Protection Agency developed an electrostatically enhanced pulse jet fabric filter. The objective of this development was to provide increased particle removal efficiency while operating at a reduced pressure loss. The design for this electrostatically enhanced fabric filter was patented by the EPA; GE Energy is the exclusive licensee of this technology which we market as Max-9™.

The Max-9™ technology combines high-voltage discharge electrodes and fabric filters in a common casing (Fig. 1). Dust-laden gas enters the unit inlet and travels up through the rows of filters. High-voltage discharge electrodes surround each filter in a grid pattern and negatively charge the particles. The charged particles move to the surface of the filter bag where they are retained.

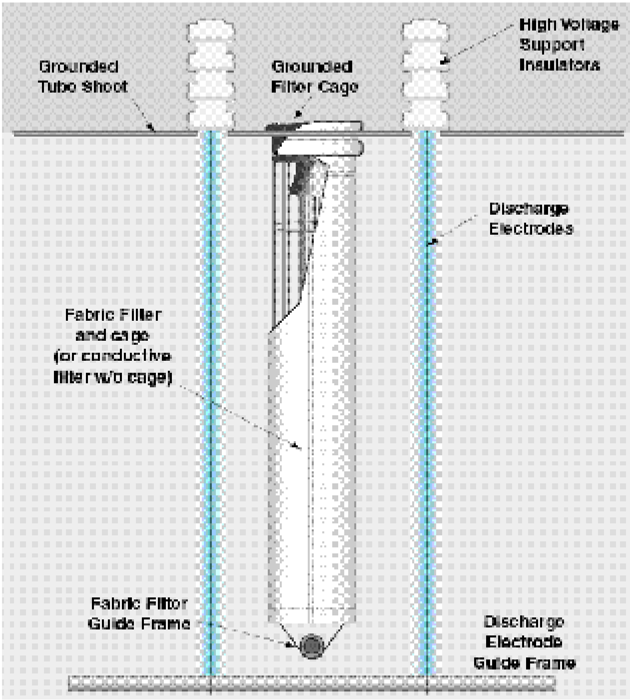

Fig. 1 – Illustration of internal discharge electrode and filter arrangement

Rather than becoming a dense, compacted dust layer typical of a traditional fabric filter, the "like" charged particles repel each other on the surface of the fabric filter, creating a porous dust layer that allows process gas to flow more freely through the filter. This is the secret of the Max-9: high efficiency particulate removal occurs at a low pressure drop.

In the Max-9, the surface of the filter bags is in close proximity to the discharge electrode. As a result, as charge bleeds off to ground through the dust layer, the discharge electrodes are able to restore charge on the dust particles. Therefore, the particles are continuously repelled from each other, maintaining porosity and a non-agglomerated dustcake. This is a major difference between the Max-9 collector and other fabric filters incorporating electrical fields. The Max-9 collector does not rely on pre-collection of particulate to achieve low pressure drop and high air-to-cloth ratios.

The electrical field has distinct impact on the system pressure losses, as illustrated by the following chart (Fig. 2). A Max-9 collector was tested under the same process conditions with the electrical field energized and de-energized for a two-hour period to observe the differences in system pressure.

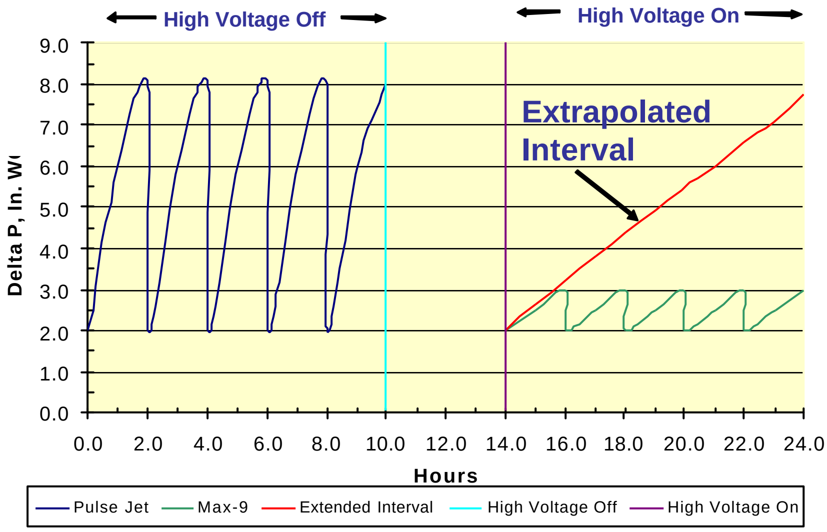

Fig. 2 – Illustrating energized and de-energized field effects on system pressure

When the electrical field was de-energized, the pressure increases from abut 50mm w.c. to over 200mm w.c. in a two-hour period. When the same collector operated with the electrical field energized, the system pressure losses increased from about 50mm w.c. to 75mm w.c. in a two-hour period. The presence of the energized electrical field reduced pressure drop by about 125mm w.c. with the same amount of dust on the surface of the filter bags.

The charged dust on the surface of the filters repels fine dust particles, preventing them from reaching the surface of the filter bag. The result is agglomeration of fine dust prior to reaching the filter media. This is the mechanism that allows the Max-9 to exhibit extremely high particulate removal efficiencies at very low system pressure drop (Fig. 3). This is a major shift from conventional fabric filters where high pressure drop is required to achieve high efficiency particle removal.

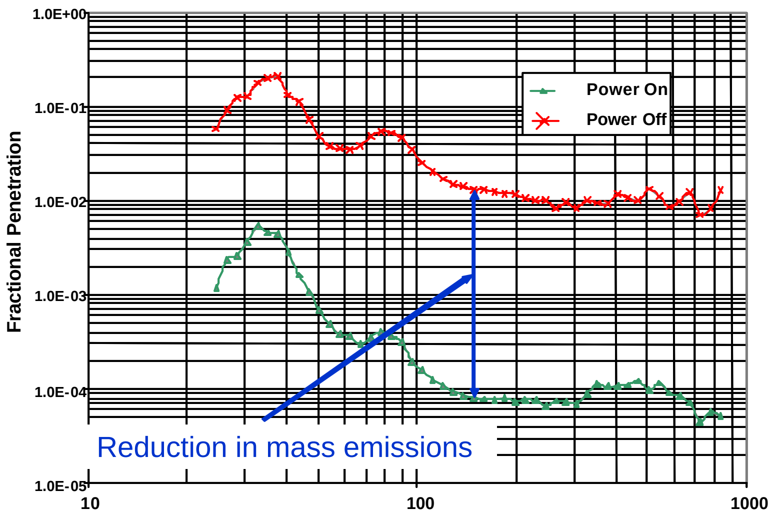

Fig. 3 – Reduction in mass emissions

BENEFITS OF THE MAX-9™ APPROACH

The air-to-cloth ratio at which the Max-9 collector can operate is higher than typically achieved by conventional pulse jet filters. Air-to-cloth ratio is the value resulting from dividing the quantity of gas treated by the total available cloth area. As the air-to-cloth ratio value increases, the size of the collector decreases. The ability to operate at higher air-to-cloth ratios allows for a smaller casing to treat the gas volume. Maintenance economies are experienced due to a reduced quantity of filter elements.

The ability to operate at low pressure drop while achieving high particulate removal efficiency provides flexibility in terms of how the Max-9 is applied:

- Low pressure drop, with normal pulsing cycles
- Conventional pressure drop, with extended cleaning cycles

Operating in the low pressure drop mode provides reduced operating costs. Fan horsepower necessary to overcome system losses is reduced. If the existing induced draft fans can accommodate a small increase in pressure losses, there is potential to reuse the existing fans with a Max-9 configuration. This represents a major cost savings to the operator.

Operating in the conventional pressure drop / extended cleaning cycle mode brings significant benefits where sorbents are used for pollutant control. Our testing indicates that if the sorbent is allowed to remain undisturbed for an increased period of time, sorbent utilization is improved. As a result, more of the pollutant can be removed with less sorbent.

The following chart indicates the amount of mercury reduction that occurs over time when the sorbent remains relatively undisturbed on the filter cake (Fig. 4). This chart is based on field test data gathered on a pulverized coal-fired boiler.

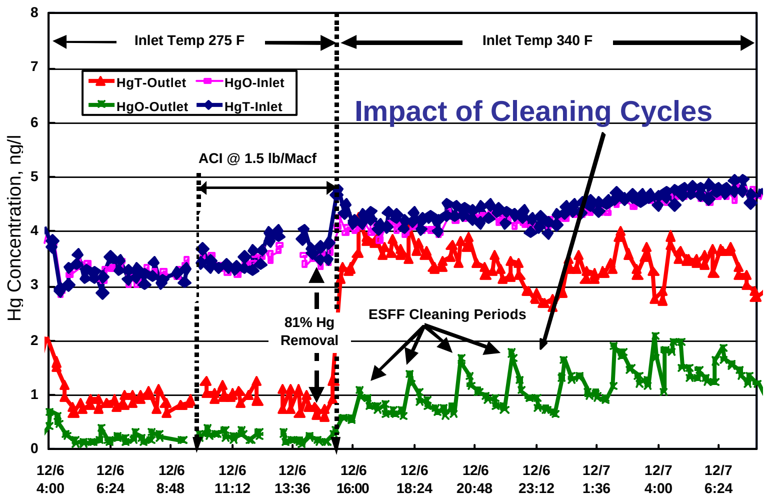

Fig. 4 – Impact of Cleaning Cycles

MERCURY DATA

Multiple field trials have been completed using the Max-9 fabric filter as part of an overall mercury reduction strategy.

Slipstream testing on a pulverized coal-fired boiler burning Powder River Basin (PRB) coal showed significant mercury reductions when the Max-9 system was used to collect particulate matter. Without using activated carbon sorbent, the Max-9 collector exhibited mercury reductions of 50% to 85% when the gas temperature was approximately 135°C (275°F).

The following chart demonstrates the mercury reductions experienced over time when the Max-9 system was operating (Fig. 5). The dynamic reduction ranges are due to changes in process conditions. Note that the incoming mercury was essentially 100% elemental. Elemental mercury is more difficult to adsorb than ionic mercury, the other common form.

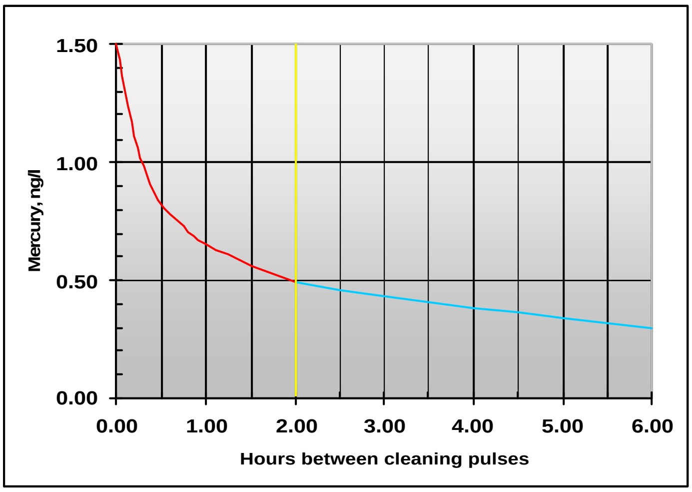

Fig. 5 – Hg reduction with extended cleaning interval

The next chart demonstrates the impact of cleaning interval on mercury reduction efficiency (Fig. 6). The green line indicates the relative quantity of elemental mercury in the gas stream. The peaks in the line correlate to the two hour pulse cleaning cycle. At the end of a pulse cycle, the elemental mercury levels were at the highest point. Immediately prior to a pulse cleaning cycle, the mercury levels are at their lowest. This is an indication that the mercury continues to be adsorbed by sorbent residing in the surface of the filter bags. When the pulse cleaning cycle is extended, sorbent utilization will be improved.

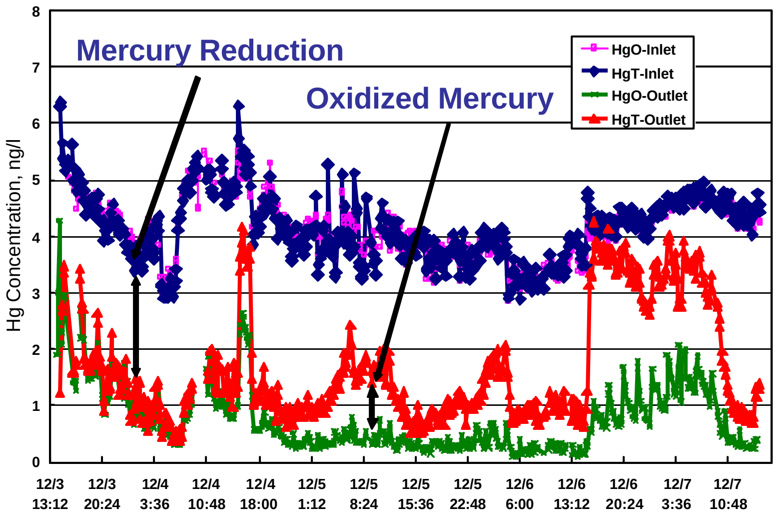

Fig. 6 – Hg reduction over time with Max-9™ system

The following chart shows the impact of injecting brominated activated carbon into the process gas stream (Fig. 7). When 1 lb/mmACF of brominated activated carbon is injected, total mercury is reduced by approximately 75%. Gas temperature was 154°C during the testing. When the injection rate is increased to 2 lb/mmACF, total mercury is reduced approximately 90%. This data is based on burning a western U.S. coal with very low chloride content. During testing, the interval between pulse cleaning cycles was about three to four times longer than that for a conventional pulse jet fabric filter.

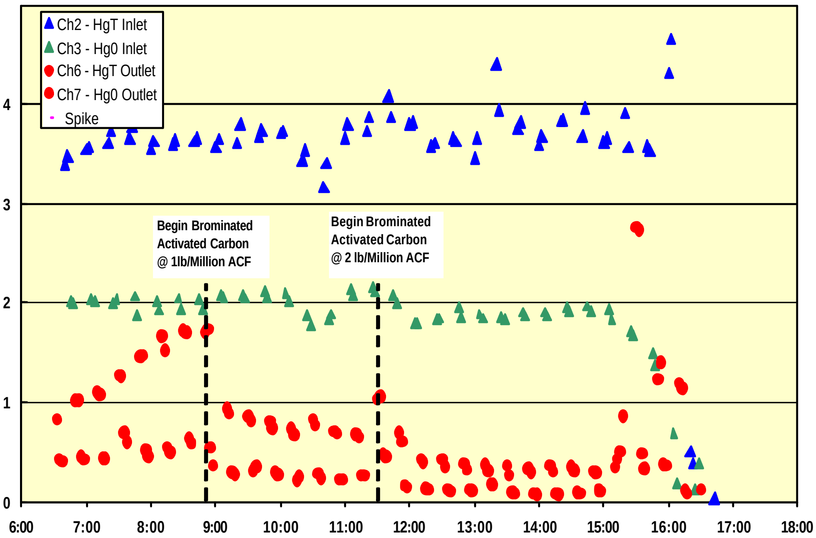

Fig. 7 – Cleaning interval impact on Hg reduction efficiency

Field testing to evaluate mercury removal has been performed at multiple locations using the Max-9 technology. The summary of results related to these tests indicates that conventional powdered activated carbon can achieve mercury removal levels of greater than 90% when the gas temperature is above 150°C (302°F). The injection rates to achieve this removal level are approximately 3 to 4 lb/mmACF.

When brominated activated carbon is utilized, mercury reduction levels comparable to powdered activated carbon can be achieved with about half the injection rate. This provides a more economical means of achieving high-level mercury removal.

SUMMARY

Based on field trials of the Max-9™ electrostatically enhanced fabric filter, the following conclusions can be made:

- The electrical field reduces the system pressure losses by a factor of three to four times compared to a conventional pulse jet fabric filter.
- Particulate removal efficiencies are one to two orders of magnitude greater for a Max-9 collector compared to a conventional fabric filter.
- The ability to increase the interval between pulse cleaning cycles increases bag life.
- When operating at an air-to-cloth ratio higher than a conventional pulse jet fabric filter, the Max-9 collector foot print will be smaller.
- Mercury removal efficiencies of 90%+ are possible when injecting 2 lb/mmACF of brominated activated carbon ahead of a Max-9 collector.
- Increasing the interval between pulse cleaning intervals improves sorbent utilization.